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ABSTRACT

In this study of the development of logical propositions in children, two hypotheses were tested: (1) There will be a significant difference in the scores and proportions of students from age level to age level in the ability to supply missing elements of syllogisms, and (2) There will be a hierarchy of difficulty for all subjects in supplying missing portions of syllogisms with the missing conclusion being supplied most frequently, minor premise second most frequently and major premise least frequently. Subjects were 140 children, 20 from each of the age levels from 4 to 10, drawn from two private middle class schools. A specially designed instrument was administered orally to each child. A 7 x 2 x 3 factorial ANOVA (age, form and elements) revealed significant F values for main effects of age and element. It was found that there was a developmental sequence in the ability of children from ages 4 to 10 to supply missing elements of syllogisms. The younger the age the lower is the score. It was also found that children were able to generate missing conclusions more easily than they could generate missing major premises. (MS)

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THE DEVELOPMENT OF DEDUCTIVE LOGIC IN YOUNG CHILDREN

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THE DEVELOPMENT OF DEDUCTIVE LOGIC IN YOUNG CHILDREN[1]

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There is a growing body of literature exploring various aspects of deductive logic including investigations by Gardiner (1965), Ennis and Paulus (1965), Roberge and Paulus (1971) and others. As Roberge's (1972) summary of research indicates, the bulk of the work has utilized subjects from the fourth grade up. This may be due in part to Piaget's influential position that children are not able to handle propositional logic until around 11 or 12. The few studies that have been conducted with subjects under grade four, which is approximately age ten, provide evidence of the ability of these younger children to think logically although there are some problems with the instruments that were used (e.g., Hill, 1961; O'Brien and Shapiro, 1968). Conversations with young children and observations of children in preschool settings by Wolf and Shigaki (1975) indicate that some children, even as young as four years of age, are beginning to think logically as evidenced by their ability to generate components of a syllogism. Given these preliminary indications and the dearth of developmental data under grade four, a focal point of the present investigation was to study the development of logical propositions in children from ages four through ten.

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The few studies of logic that have been conducted with young children have focused primarily on determining the adequacy of a conclusion to a syllogism. However, it appears that there is a differential ability of children to respond depending upon the element of the syllogism which is being considered. In a previous study by Shigaki and Wolf (1975), recognition of the components of a syllogism by fifth grade subjects appeared in a hierarchical order. The ordering of the elements in the hierarchy was as follows: conclusions were recognized most often, minor premises came next, and major premises were recognized least often. Consequently, the second objective of the present study was to determine whether or not this hierarchical ordering would hold for younger children when they were required to generate the missing element.

A common mode of instrumentation for research of logic with children under the age of ten has been the use of concrete materials (Ennis, 1971; Fitzgerald, 1973; Kodroff and Roberge, 1975). Hill devised an instrument which differed by requiring only a verbal response. Her findings were questioned by O'Brien and Shapiro who suggested that the yes-no test format utilized lent itself to guessing. They revised her test by including "not enough clues" in the response choice of some of the items to make them more "open." It was reported that children avoided the more open response, however, even doing poorer than simple random guessing. Given some of the difficulties of the forced-choice format, an instrument requiring the child to generate the appropriate answer was devised for this study.

Hypotheses

The hypotheses of the study were as follows:

Hypothesis 1: There will be a significant difference in the scores and proportion of students from age level to age level in the ability to supply missing elements of syllogisms. The younger the child, the lower will be his score on a test requiring him to generate missing premises in syllogisms.

Hypothesis 2: There will be a hierarchy of difficulty for all subjects in supplying missing portions of syllogisms with the missing conclusion being supplied most frequently, minor premise second most frequently, and major premise least frequently.

Sample

Two comparable private schools with a predominately middle-class student body constituted the population from which the sample for the study was drawn. Each school enrolled between 150 and 200 students from ages four through ten. This particular population was selected since the investigators felt that if children were able to respond correctly to the items at the lower age levels it would most probably occur at this type of school. Since the study was to determine if children could respond at all at the various age levels, these schools were considered appropriate for the study. Further, preliminary pilot studies, with middle-class children similar to those in the two schools selected, indicated that the assumption above was in fact a viable one. The sample was comprised of 140 children, 20 from each of the age levels from four through ten. Parental permission for working with each child was required by each school and was received from over 90% of the population. Subjects were randomly selected from those children for whom permission was obtained.

Instrumentation

The instrument for measuring children's knowledge of missing elements in syllogisms was developed with refinements being made based on information acquired through a series of pilot tests. The major problem encountered early in the piloting was the need to "let the children in on the game," i.e., to encourage children who free-associated with the content of the item to work within the closed system of the syllogism. Consequently, a sample item was added to the test and both nonsense and regular syllogisms were included. As a result of these refinements, the final instrument which contained twelve items took two basic forms. In one form, six nonsense syllogisms were followed by six regular syllogisms; in the other form, the order was reversed. An equal number of items with missing major premises, missing minor premises and missing conclusions was included. The single sample item on each test form was one of six varieties: nonsense or regular with a missing major premise, missing minor premise or missing conclusion. Finally, to avoid possible reading difficulties, and to accommodate children of ages four and five, the test was developed for oral administration using short syllogisms which could easily be retained. A sample item which is representative of the items on the test took the following form:

Missing conclusion
All frogs jump.
Shelley is a frog.
So? What follows?

The nonsense items were parallel in form, e.g., "All frogs jump." was converted to "All blims jump."

Test-retest reliability of the instrument was established with a subgroup of the sample, five children each from ages five, seven and nine, for

a total of fifteen subjects. One week intervened between testing sessions. A high reliability of .88 was established.

Procedure

A team of five testers was carefully trained to administer the test of logic. Included in the training program were sessions devoted to listening to tape recordings of children of various ages responding to the instrument together with a critiqueing of the procedures. All testers were required to administer the instrument to several children prior to actual data collection and to tape record these interactions. These tapes were reviewed and individual feedback sessions were held to insure that uniform testing procedures would be followed.

Data were collected through an individual oral session with each child in a quiet private room located in each school. Each child's responses were recorded on test forms and simultaneously tape recorded. The first few minutes of each session were used to establish rapport, obtain background information on the child, and introduce the test with the sample item. Following the child's response to the sample item, he was told the correct answer. On the test proper, testers were instructed not to indicate to the child whether or not his response was correct, but to merely respond with a noncommittal "OK" before proceeding to the next item. To provide closure for the child at the end of the session, he was asked a few questions about himself and given the opportunity to listen to that segment of his tape. The child was requested not to share the content of the session with other children. Each session lasted approximately twelve minutes. Counter-balancing was utilized across all age levels to eliminate the effects of sample item, tester, room, and time of day.

Results

Each protocol was scored by two judges working independently. Out of a total of 1680 items to be scored (12 items x 140 subjects) there was disagreement on only 14 items. In these few cases of disagreement, the tape recordings were consulted and a mutual decision between the two judges was reached.

A 7 x 2 x 3 factorial analysis of variance with repeated measures on the last two factors was employed for the study (Winer, pp. 539-559). The factors consisted of seven levels of age, two levels of form (nonsense and regular), and three levels of element. The results of this analysis are presented in Table 1. As can be seen from this table, a significant value beyond the .01 level was obtained for the three main effects of age, form and element as well as for two interactions, age x form and age x element.

Insert Table 1 about here

The Scheffé test was utilized to determine where the significant differences occurred concerning the main effect of age. The results are found in Table 2. As can be seen from this table, the mean differences

Insert Table 2 about here

become larger with an increase in age span. Further, the data presented in Table 3 show a definite progression in frequency and percentage of correct responses from age four to age nine with only a small increment from age nine to age ten. Thus, hypothesis one is confirmed.

Insert Table 3 about here

TABLE 1

ANALYSIS OF VARIANCE FOR AGE, FORM, AND ELEMENT

Source	SS	df	MS	F
Between subjects				
Age	137.21	6	22.87	22.87*
Subjects within groups	133.66	133	1.00	
Total	270.87	139		
Within subjects				
Form	1.46	1	1.46	8.11*
Age x Form	6.05	6	1.01	5.61*
Form x Subjects within groups	23.32	133	0.18	
Element	182.72	2	91.36	157.52*
Age x Element	41.20	12	3.43	5.91*
Element x Subjects within groups	153.08	266	0.58	
Form x Element	1.11	2	0.56	2.80
Age x Form x Element	2.27	12	0.19	.95
Form x Element x Subjects within groups	54.29	266	0.20	
Total	465.50	700		

* Significant beyond the .01 level.

TABLE 2

SCHEFFÉ TEST FOR DIFFERENCES BETWEEN MEANS BY AGE
(Total Correct Responses)

Age	5	6	7	8	9	10
4	.95	2.80*	4.50*	5.55*	6.40*	6.50*
5	-	1.85*	3.55*	4.60*	5.45*	5.55*
6		-	1.70*	2.75*	3.60*	3.70*
7			-	1.05	1.90*	2.00*
8				-	.85	.95
9					-	.10

Age

*Significant beyond the .01 level.

TABLE 3

RESPONSES BY AGE AND ELEMENT
(Frequency and Percentage of Correct Responses)

Age	Conclusion		Major Premise	
	No. Correct	% of Possible	No. Correct	% of Possible
10	78	97.5	23	28.8
9	77	96.3	22	27.5
8	71	88.8	18	22.5
7	65	81.3	11	13.8
6	51	63.8	8	10.0
5	21	26.3	17	21.3
4	15	18.8	4	5.0

The Scheffé test was also utilized to determine where significant differences occurred between elements. The analysis revealed that there were significant differences at the .01 level between conclusions and major premises. Hence, hypothesis two was only partially confirmed.

The significant interaction effect for age x form is presented in Figure 1. As can be seen from this figure, the magnitude of the difference

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Insert Figure 1 about here

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between the nonsense and regular forms was not consistent across all age levels. In order to determine exactly at which ages the difference between nonsense and regular forms is significant, tests for the difference between simple main effects were computed (Winer, p. 544). These pair-wise comparisons presented in Table 4 revealed that there were significant differences between the two forms in favor of the regular form at ages four, five and six and in favor of the nonsense form at ages seven and ten. No significant differences were found at ages eight and nine.

Insert Table 4 about here

Discussion

As hypothesized, there was a developmental sequence in the ability of children from ages four to ten in supplying missing elements of syllogisms. There is a definite progression with age which continues up to age nine at which point there is a leveling-off effect (See Table 3). This developmental sequence in the supplying of missing propositions is assumed by the

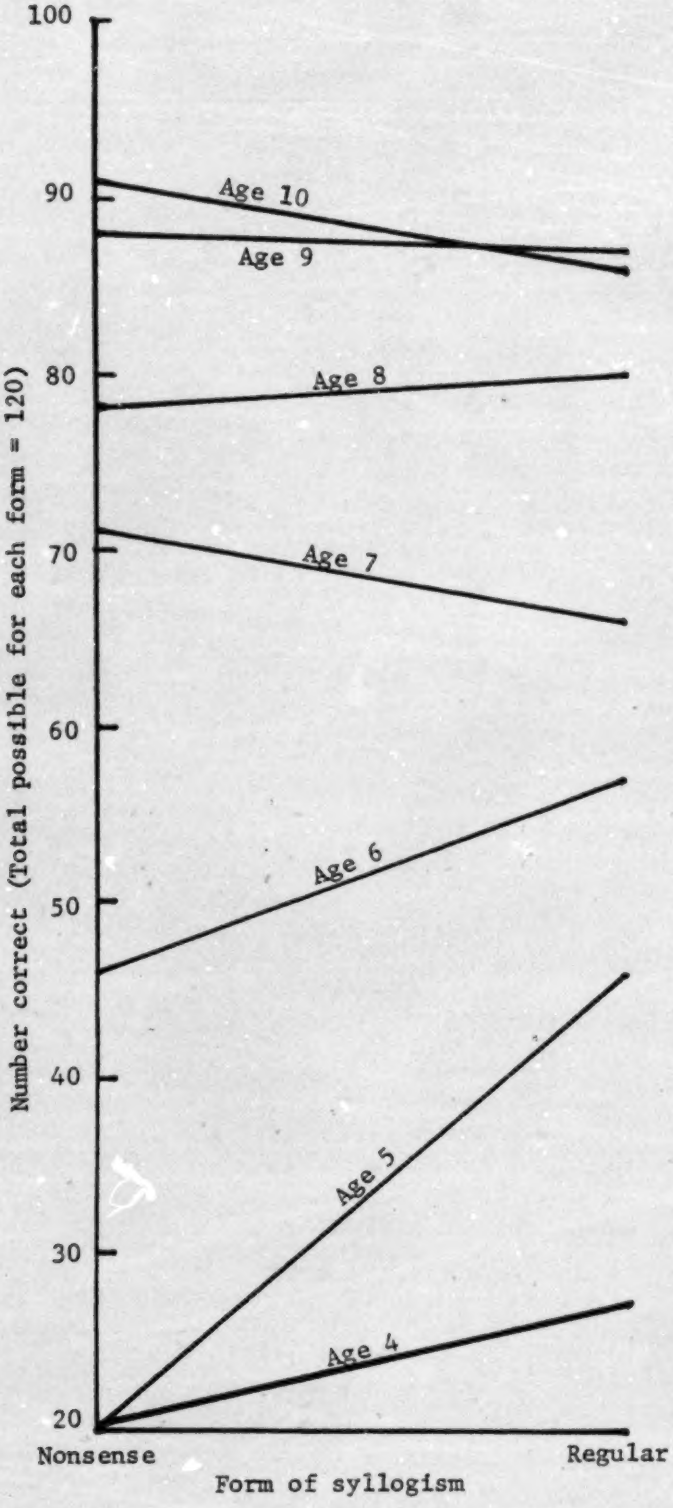

FIGURE ONE

RESPONSES BY AGE AND FORM

TABLE 4

DIFFERENCES BETWEEN NONSENSE & REGULAR FORMS RESPONSES BY AGE LEVEL

Age	Form		t
	Nonsense	Regular	
10	96	91	3.27*
9	88	87	.64
8	78	80	-1.29
7	71	66	3.23*
6	46	57	-7.10*
5	20	46	-16.78*
4	20	27	-4.50*

*Significant beyond the .01 level.

investigators to represent a steady increase in the children's deductive reasoning ability. There were a few children among the four- and five-year-olds, however, whose scores approximated the average score of children in the eight-, nine-, and ten-year-old groups. The only items these younger children did not generate were the missing major premises, thus they had approximately two-thirds of the items correct. This behavior is consistent with the investigators' previous observations that some children of four and five are capable of doing logical reasoning.

Concerning the second hypothesis which deals with the hierarchical difficulty of the syllogistic elements, it was found that children were able to generate missing conclusions much more easily than they were able to generate missing major premises (See Table 3). As noted in Table 3, there was a wide range of correct responses for generating missing conclusions, i.e., 19% to 98%. The range of correct responses for missing major premises was considerably more constricted, from 5% to 29%. Thus even by age ten though most of the children were able to supply virtually all of the missing conclusions, they were able to supply less than a third of the missing major premises. An inspection of the data showed that the test items for generating minor premises were actually operating as syllogisms with missing conclusions. Therefore, Hypothesis 2 did not receive adequate testing for the difference between missing minor premises and the other two elements. While it is obvious that missing conclusions are easier than missing major premises, the minor premise needs further study.

In summary, the major conclusions of the study are as follows:

1. There is a developmental sequence in the ability of children from ages four to ten to supply missing elements of syllogisms. The younger the age, the lower is the score.

2. There is a hierarchy of difficulty for all subjects in supplying some missing portions of syllogisms with the missing conclusion being easier than the missing major premise.

These conclusions are applicable to subjects similar to those in this study. Further research is necessary at this point to determine the generalizability of the results to children of varying backgrounds. Since it has been shown that for children as young as four an instrument requiring the generation of logical responses is a viable technique, further use of similar instrumentation in future studies appears warranted. The investigators are currently refining their instrument to adequately assess all three elements of a syllogism. Subsequent developmental studies might also increase the age range explored and systematically extend the logical principles investigated.

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